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S4D4C USING SCIENCE FOR/IN DIPLOMACY FOR ADDRESSING GLOBAL CHALLENGES

The 'Matters' of Science Diplomacy: Transversal Analysis of the S4D4C Case Studies

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Preface

This transversal analysis is the second in a set of two volumes coming out of the case study work package of the Horizon 2020 project S4D4C, 'Using science for/in diplomacy for addressing grand societal challenges' (see box 1). The first volume, 'Science Diplomacy in the Making: Case based insights from the S4D4C project', individually presented the nine case studies that we researched in the project (see box 2), delving into the governance arrangements, knowledge dynamics, multilevel actor constellations, and the ways that specific case could advance and refresh our understanding of science diplomacy. In this second volume, we take a comparative approach, looking across all nine cases for insights and lessons that can inform and improve both the practice of science diplomacy and future academic work on the topic.

When we began the transversal analysis of our case studies, we asked a simple question: What matters in science diplomacy? The idea here was threefold, playing on different meanings of the word 'matter'. First, there appeared to be something 'the matter' with attempts to define the concept of science diplomacy. While there is a well-established and useful typology (AAAS/Royal Society 2011), the transition from that to a comprehensive definition and/or theory of science diplomacy has been elusive, likely because the concept covers such a vast and complex array of actors, institutions and practices. Our initial case study design was intended to both capture this conceptual breadth, as well as to provide a different set of lenses through which to examine it. We divided our cases into three categories, based on what we saw as the primary (though not exclusive) driving force behind them as they engaged the intersection of science and diplomacy in the pursuit of addressing global challenges. There were foreign policy-driven cases, which use science to advance already existing European foreign policy goals and its position in the global community; these we called diplomacy challenges, as the challenge was getting the science more deeply integrated into diplomatic activities. There were science-driven cases, which looked at areas where European science and research communities were positioned as global leaders, and thus provided likely opportunities to potentially impact on international affairs. Finally, there were instrument-driven cases, in which existing policy instruments, infrastructures and institutions were being extended externally and used as models globally by the EU and Member States. This wide-ranging, three pronged approach provided a diverse array of empirical data from which to explore and seek out new themes in science diplomacy.

Second, we draw on the meaning of matter as a 'subject or substance'. We have sought to find concrete, though not physical, aspects of science diplomacy that run across multiple cases. We recognize that science diplomacy is not singular in its actors, institutions, processes, or activities. The resultant multiplicity of variables leads us to put forward a diverse set of 'matters' of science diplomacy, each of which homes in on a specific aspect of science diplomacy and through examples derived from our case study research, investigates its significance.

The third meaning of matter is to be 'important or consequential'. This is the most critical of the three meanings for our purposes in this volume. The aspects of science diplomacy that we explore in the pages below are, we believe, important for advancing the understanding of science diplomacy as a concept and a practice.

We conceive of the matters in this report as an integrated mosaic with a myriad of possible linkages and intersecting effects between them: like in complex systems, when the metaphorical butterfly flaps its wings in one matter, it affects - perceptibly and imperceptibly - other matters as well. Some linkages between the matters are identified in the text below, but many remain as a task for future research, and we hope that you will join us in furthering this discussion. To that end, we have identified the main authors of each matter, both to give credit where it is due, but also to provide you, the reader, with contact points for the various topics.

Finally, we wish to express our appreciation to the participants in two focus groups that were held in the autumn of 2019 in Berlin and Budapest, in which we preliminarily explored some of these matters and discussed future scenarios for science diplomacy. As well, we would like to thank the whole S4D4C project team, as the findings in this volume are the results of discussions that have occurred throughout the projects lifetime and across the work packages.

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Box 1 – The S4D4C project – "Using science for/in diplomacy for addressing global challenges"

"In the current political and societal landscape, the needs, stakes and opportunities pertaining to science diplomacy have increased. However, communication between the scientific and diplomatic communities is not straightforward. There is potential for better harnessing European science and science cooperation for European science diplomacy and foreign policy goals, both at the EU and EU Member State-level. Not only can new approaches to scientific advice in EU foreign policy benefit from advances in research, but science diplomats can also harness new ways of carrying out research that offer opportunities for foreign policy impact. The overall objective of S4D4C is to support current and future European science diplomacy for the benefit of European capacities, EU foreign policy goals and especially the development of solutions for grand societal challenges. S4D4C has shaped its partnership so that it can effectively address this objective from an academic as well as a practitioners' perspective." (www.s4d4c.eu)

To access other publications of the S4D4C project, please visit www.s4d4c.eu/outputs.

Box 2 – S4D4C case research

Diplomacy challenges – Foreign policy driven cases

- Science diplomacy and infectious diseases: Between national and European narratives (Šlosarčík et al., 2020)
- Water diplomacy and its future in the national, regional and European environments (Tomalová et al., 2020)
- Cyber Security: Mapping the role of science diplomacy in the cyber field (Kadlecová et al., 2020)

Science opportunities – Science driven cases

- The science and diplomacy of global challenges: Food security in EU-Africa relations (Ravinet et al., 2020)
- International dimensions of the EU's FET Flagships: Large-scale strategic research investments as a site of de-facto science diplomacy (Degelsegger-Márquez, 2020)
- Open Science Diplomacy (Mayer, 2020)

Coordination options – European instrument driven cases

- SESAME – a synchrotron light source in the Middle East: an international research infrastructure in the making (Rungius, 2020)
- Joint international research programming as a case of science diplomacy (Flink, 2020)
- Science advice in the European Union: Crafting collective understanding of transnational issues (Montana, 2020)

To access the case studies please visit https://www.s4d4c.eu/s4d4c-cases/

The compiled nine-case volume, Young, M., Flink, T. and Dall, E. (2020). Science Diplomacy in the Making: Case-based insights from the S4D4C project, can be downloaded directly here: https://www.s4d4c.eu/wp-content/uploads/2020/03/S4D4C_REPORT_Science-Diplomacy-in-the-Making.pdf

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List of Acronyms

AAAS	American Association for the Advancement of Science
AEGIS	Accelerating EU-US Dialogue for Research and Innovation in Cybersecurity and Privacy (Horizon 2020 project)
AU	African Union
CERN	European Organization for Nuclear Research
CFCs	Chlorofluorocarbons
DGs	Directorate-Generals of the European Commission
DEVCO	Directorate-General for International Cooperation and Development
DG AGRI	Directorate-General for Agriculture and Rural Development
DG ECHO	Directorate-General for European Civil Protection and Humanitarian Aid Operations
DG RTD	Directorate General for Research and Innovation
EC	European Commission
ECDC	European Centre for Disease Prevention and Control
EEAS	European External Action Service
ERA-Net	European Research Area networks (a project type in the Framework Programme)
EU	European Union
FAO	Food and Agriculture Organization
FET	Future Emerging Technologies
GHSI	Global Health Security Initiative
HE	Higher Education
GloPID-R	Global Research Collaboration for Infectious Disease Preparedness
HLPD	EU-Africa High Level Policy Dialogue
ICPDR	Convention on Cooperation for the Protection and Sustainable Use of the Danube River
ICT	Information and communication technology
JPI	Joint Programming Initiatives
MS	Member State (of the EU)
NATO	North Atlantic Treaty Organization
NCISA	National Cyber and Information Security Agency (Czechia)
NGOs	Non-governmental organizations
PRIMA	Partnership for Research and Innovation in the Mediterranean Area
R&I	Research and Innovation
SAGE	Scientific Advisory Group for Emergencies(UK)
SPIDER	Science Policy in Diplomacy and External Relations network
SESAME	Synchrotron-light for Experimental Science and Applications in the Middle East
STI	Science, Technology, and Innovation
UK	United Kingdom
UN	United Nations
US	United States
WASP	Central Asian Regional Water Stakeholder´s Platform
WHO	World Health Organization
ZIG	Centre for International Health Protection

Matters of Science Diplomacy

1. Explicitness/Implicitness

Explicitness (or implicitness) refers to the use (or non-use) of the term 'science diplomacy' by particular actors in particular situations to label themselves or their activities. While the term science diplomacy has been gaining increased traction in both academic and policymaking circles, it is neither universally embraced nor entirely consistently used. The reasons for this are undoubtedly manifold: sometimes they are intentional and other times they reflect a lack of awareness of the concept or a preference for alternative language. In this matter, we look at the conditions under which actors choose to use or to avoid the term science diplomacy, and by distinguishing between explicitness and implicitness, seek to make sense of one aspect that underlies the ambiguity of science diplomacy as a term.

Our basic premise is that the act of applying (or not applying) the label science diplomacy to a concrete interaction, practice or actor is political, that is, it creates and changes power relations and affects outcomes. Casting the term this way makes it especially important not to overlook instances at the intersection between science and diplomacy that are not named explicitly as science diplomacy. In our S4D4C cases, we found quite a few examples of things that we believe should be considered science diplomacy even though they are not labelled as such or occur under the label of an alternative (sub) type of diplomacy or policymaking. Science diplomacy, in other words, is not solely identifiable through self-conscious labelling but requires looking more broadly into what occurs at the intersection of science and international relations. Understanding when, in what context, and for whom the explicit use of the label science diplomacy is helpful in efforts to advance scientific and foreign policy objectives, and inversely, understanding when, in what context, and for whom science diplomacy may be more effectively deployed by leaving the term unstated, provides insight into science diplomacy as both a practical and theoretical concept.

The term science diplomacy is used to label both actors and practices. There are three main types of actors that engage in activities of science diplomacy: (1) political/diplomatic actors, (2) science-based actors, and (3) science administration/management-based actors. In each of these three actor types, we can distinguish between explicit and implicit actor self-definition. In the first type, we find both explicit and implicit actors. There are actors with explicit roles and titles that include the term science diplomacy: Science Diplomats, Science and Technology (S&T) attachés, and Special Envoys, whose role is to practice science diplomacy. More precisely, their role is typically to practice 'diplomacy for science', that is, assisting scientists in bridging national divides, and these actors have little to do with high politics or sensitive diplomatic issues. Inversely, in this first type, we also find political actors (from civil servants to high-level politicians) that work on knowledge-intensive issues and are thus engaged in practices that we could consider to be science diplomacy, but they do not define themselves as science diplomats. The second type, science-based actors, mainly do not use the term science diplomat to define themselves or their actions, though there is a small but growing cadre of scientists that would do so. In this second type, we distinguish between government-appointed and self-appointed science diplomats. Government-appointed science diplomats are scientists who are brought in by the government to assist in knowledge-intensive negotiations and decisions on what may be sensitive diplomatic topics. A prototypical example here is the Iran nuclear negotiations. These government-appointed actors would not likely call themselves science diplomats, though we would classify them that way. Self-appointed science diplomats, on the other hand, are activist in nature. These are scientists who attempt to impact on issues of international affairs, engaging with a wide range of global challenges and sustainable development goals. This sub-type of actor uses the term explicitly, and these actors are often associated with institutions that promote science diplomacy activities, such as the trainees and members of various networks (e.g. "Science Policy in Diplomacy and External Relations" (SPIDER)). Finally, the third type of actor, science administrators, are engaged in international issues and have responsibilities that entail some degree of diplomatic activity – joint programming, grant and infrastructure management – but who would not explicitly refer to themselves as science diplomats. Overall, we can say that the explicit identifier 'science diplomat' is generally reserved for a sub-set of the actors that actually practice science diplomacy. Interestingly, while the term science diplomat is used rather cautiously and often seems to be a conscious and considerate choice, the term science diplomacy, referring more to practices than actors, has gained wider traction.

Turning our attention to practices, the cases we have studied provide a number of different ways of looking at the implicit or explicit use of the term. The key to understanding its use in practice relates to two factors: objectives and legitimacy. Regarding objectives, it is important to ask whether or not the term science diplomacy advances or hinders diplomatic objectives. While we find many examples of the positive impacts of the explicit use of the term in our cases and in the general literature on science diplomacy, two of our cases shed a slightly different light on this question. In the case on food security, we found that explicitly labelling an activity as one of science diplomacy can be seen to introduce a non-cooperative dimension – or a quid pro quo, which changes the dynamics of what otherwise would be purely scientific cooperation (Ravinet et al., 2020). In this way, an action that is altruistic may be seen as self-interested. In such situations, the word science diplomacy is better avoided, as it is likely more effective to keep to the language of scientific cooperation, steering clear of any invocation of politics. The political effects this term has also depend on the institutional logic in different sectors of government. While science diplomacy, practised as cooperation by those in the science and research sectors of government, is most often undertaken with the universalistic aim of advancing science, for other sectors, it has different uses. Within the foreign policy apparatus, it is often viewed as a trading chip within a broader negotiation framework. For example, funding for food research cooperation may be traded for concessions in other areas, such as strengthening control over migration. What is perhaps unexpected then, is that we find a reluctance to use the term in foreign policy, particularly in the European External Action Service (EEAS), and we find its strongest promoters in the research ministries, for which it is something of a double-edged sword.

The second case which sheds light on this issue is Synchrotron-light for Experimental

Science and Applications in the Middle East (SESAME) (Rungius 2020). The SESAME infrastructure is commonly presented as a poster child of science diplomacy. The narrative, in its most simple form, is that SESAME promotes world peace by bringing together countries traditionally in conflict through a joint scientific infrastructure. While there is truth behind this narrative, and there are examples of the participating countries coming to agreements in order to establish and run the facility, the cooperative successes, somewhat paradoxically, tend to relate to administrative issues (such as budgets) rather than scientific ones. Notably absent, for the time being, is evidence of individual-level cooperation between scientists of different nations as a means of building cross-cultural understanding. What is important for the discussion on explicitness, is that the most prominent narrative, peacebuilding through science diplomacy, is potentially counterproductive for achieving what most of the regional participants want from the project – the ability to conduct cutting edge research. Internally, SESAME strives to define itself by excellent science, but the narrative of peacebuilding tends to overshadow the scientific goals.

A second key factor for understanding the use/non-use of the term in practice is that of legitimacy. The explicit use of the term should enhance the legitimacy of the relevant actors and their practices, or else there is no reason to use it. Since it is difficult to identify empirical evidence that would prove a positive correlation, we, therefore, look at it the other way around, seeking reasons for not using the term in situations where science diplomacy is known to be happening. In our case studies, we find two main reasons: a lack of awareness of the concept and/or a preference for alternative concepts. There were a significant number of interviewees who were not familiar with the term until it was explained to them, at which point the interviewees generally responded positively to it and agreed that their activities fit within this category. Concomitantly, we found that other related concepts often had more salience within policy communities. In our three foreign policy driven cases, infectious diseases (Šlosarčík et al., 2020), water security (Tomalová et al., 2020), and cybersecurity (Kadlecová et al., 2020), there are corresponding diplomacies which compete with science diplomacy, namely health diplomacy, water diplomacy, and cyber diplomacy. These thematically oriented diplomacies tend to be used more often than the broader and more cross-cutting term science diplomacy. The same effect is seen in stakeholder organizations, that also tend to prefer the more thematically-specific terminologies, i.e. health diplomacy, over science diplomacy. The exception to this is in the area of science and research policy, where the term science diplomacy is common, but where it also, of course, fits the thematic focus of the ministry or agency.

The relations between actors in science diplomacy and the thematic diplomacies can be more clearly uncovered in cybersecurity, which has become a primary issue for foreign policy in a way that none of the other case topics have. There are cyber diplomats (and attachés), who often work alongside science diplomats (and attachés) in the same embassies and foreign representation offices. The distinction between their two positions and roles exposes the institutionalized gap between these interrelated concepts of diplomacy. We find that in actuality, they are treated as almost entirely separate activities: there are no formal structures or institutionalized practices to guide the relationships between them, even when they are in the same embassies. There is, nevertheless, evidence of ad-hoc cooperation (Kadlecová et al., 2020). There are significant overlaps between these types of diplomacy but also differences and gaps such that neither term fully encompasses the other. We suggest, therefore, that better articulation of science diplomacy as a cross-cutting/umbrella-like concept and sector-based types of diplomacy is needed both theoretically and in practice.

Finally, we also find that there is a great deal of variance between national approaches to the use of the term. For example, the UK tends to explicitly refer to science diplomacy more than other countries. There is also a difference in the way states make use of the term. In the Czech Republic, the term often shades in meaning towards economic diplomacy, something which we also see in the Netherlands and the UK regarding how each state addresses water diplomacy (Tomalová et al., 2020). These differences are both cultural and linguistic, and much as the word science itself varies in meaning, the concept of science diplomacy has different national meanings and connotations, furthering an already complicated question of when, in which context, and with whom to be explicit about science diplomacy.

2. Interests

National interests are a matter of principal importance in science diplomacy. On the one hand, the concept of science diplomacy problematizes (national) interests as potential obstacles to tackling global challenges. This dimension is mostly reflected in the understanding proposed by the American Association for the Advancement of Science (AAAS) and the Royal Society model, which frames science diplomacy as a matter of fostering collective action between nation states (Rungius and Flink, 2020). In that sense, science diplomacy is proposed to mitigate interests that are defined too narrowly and that do not incorporate scientific evidence. However, the concept of science diplomacy acknowledges that nation states follow their own interests. In that regard, science diplomacy is also framed as part of a country's soft power - a foreign policy instrument in the diplomatic toolbox. This soft power dimension is particularly reflected within the Science for Diplomacy dimension that is part of the AAAS/Royal Society definition. The accentuation of interests rather than practices was prominently re-accentuated by the pragmatic taxonomy of science diplomacy, brought forth by four national science advisers (Gluckman et al., 2017). This taxonomy suggests distinguishing between science diplomacy to advance national interests, to settle cross-border issues and to tackle global challenges. This notion relies on science as part of a countrys soft power, the attention of which is largely focused on advancing national interests. This understanding closely reflects the original sense of the term, when it was for the first time explicitly introduced into a foreign policy strategy. The president of the United States, Barack Obama, appointed science envoys and implemented other traditional science diplomacy measures in order to restore the damaged reputation of the United States among Arab countries and the Middle East. When science diplomacy is discussed in light of foreign or innovation policy strategies, it is primarily with an aim to represent a nations interests. In that sense, interests matter as key dimensions at least in two different ways within the concept of science diplomacy.

This ambivalent meaning of national interests within science diplomacy definitions produces an 'interest paradox' between 'competition' and openness rationales: on the one hand the promotion of a countrys scientific competitiveness and innovation potential, on the other hand, efforts to foster collaboration among countries in the international arena to tackle global challenges. How can these two scopes (competition vs cooperation) be harmonized or jointly approached, acknowledging that, in particular, competition means different things in economic (productive advantages over scarce resources), political (struggle for power) and scientific (competition for first and valid findings, and reputation games) terms? The cases of Open Science (Mayer, 2020), Future Emerging Technologies (FET) flagships (Degelsegger-Márquez, 2020), and Food Security (Ravinet et al., 2020) shed some light upon this conundrum. While Open Science is generally geared to trigger collaborative science on a global scale and is included in the international efforts to tackle global challenges, our case study also reflects the conflicts of interest that pertain to objectives of fair cost sharing, intellectual property rights, and other competitive interests (Young, 2020). Open Data or Open Educational Resources potentially face a lack of reciprocity and a dilemma of collaborative vs competitive science (Mayer, 2020). By contrast, the Future Emerging Technologies flagships were designed as a strategic and competitive science, technology, and innovation (STI) instrument to ensure innovation and economic impact remain in the EU. Third countries were principally excluded from full participation. However, within a highly internationalized science and innovation system, these protective policies did not reflect the necessary de facto international collaboration taking place behind the scenes (e.g. review system). The study identified a major challenge "for research policy instruments of the scale of the flagships to define a balance between openness and restriction, cooperation and competition." (Degelsegger-Marquez, 2020: p.127) Furthermore, this approach collides with the approaches such as the collaborative 'Open to the World' policy (European Commission, 2016), although certain cooperation regimes have been explored and established in light of the challenge to find a practicable balance between openness and competition.

On a similarly general level, but apart from national interests, one could argue that science diplomacy is also driven by the interests of the scientific system alongside political, economic, and personal interests (see Young, 2020). The 'Diplomacy for Science' dimension of the AAAS and Royal Society models highlight science as an international endeavour that comes with a number of tangible requirements, partially served or facilitated through diplomacy. In the broadest sense, the most optimistic framing of science diplomacy is the possibility of generating synergies between different systems (science and foreign policy) acting in their own interests. Framing science diplomacy as a "boundary object", bringing together the world of scientific and technological research with the world of international affairs, implicates profound challenges on the basis of seeking and combining mutual interests. Scientists and diplomats have different backgrounds and represent different interests which may be conflicting. Working closely together with diplomats and political actors, scientists may fear they will be instrumentalized for national or political interests that are not their own. Indeed, epistemic interests (the quest for knowledge) may be politicised and reinterpreted by others within a political context, e.g. they may include a political mission. This reinterpretation reverberates and can have an adverse effect on the original scientific interests that are expected to be disinterested (see Merton, 1973), apolitical or disconnected from purely political goals.

This is particularly a risk in Science for Diplomacy, or Science for Peace constellations, as demonstrated in the example of Synchrotron-light for Experimental Science and Applications in the Middle East (SESAME) (Rungius, 2020). Large scientific endeavours provide common ground to build cooperation among nonallied nations. This is the classical 'Science for Diplomacy' approach that is illustrated in the SESAME case study. In the SESAME case, scientists from across Middle-East nations collaborate in a large research infrastructure to unveil the secrets of particle physics. Such examples highlight science as a means to enhance cooperation and understanding among civilisations. While scientific development is not unique to any one civilisation, Western cultures embrace scientific development as their own. Understanding how scientific and diplomatic interests may be intertwined to prevent friction among civilisations will be key for human progress.

The ways in which interests mattered in science diplomacy constellations investigated in our case studies were often more subtle and unexpected than traditional conceptions of science diplomacy would broadly suggest. The constellations we investigated struggled less with basic conflicts of interest between general stakeholder groups than with establishing, fine-tuning and maintaining common procedures across institutional and national borders in environments with a multitude of implicit, hidden and impalpable individual and organisational interests.

The case study about joint programming looking at bilateral and multinational collaborations in science funding (Flink, 2020), showed that there was usually no conflict of interests carried out over general financial shares or budget increases. These conflicts are usually settled before entering into joint programming. In the same way, fundamental interests of the collaborating partner are not challenged as such, but partners have a general willingness to take them into account as much as possible. The difficulty lies in reaching and securing common evaluation standards in the face of divergent legalisation frameworks, routines and customs. It is also difficult to balance occasional interventions and influences from the outside that could not be predicted and sometimes could not even be explained in retrospect, because the actual reasons may they be personal, organizational or political remained in the dark. In some instances, even "insignificant decisions needed clearance from a non-transparent ministry in the back" (Flink, 2020: p.266) leading to "tedious stop-and-go decision making whilst deciding upon the procedure and the evaluation criteria" (Flink, 2020: p.266). In another case, a funding scheme was set and subsequently a ministry interfered, which in itself was not considered to be a problem. But responding to these political requests and thereby deviating from formalized procedures was feared to signal inconsequent behaviour. This may have adverse effects on further spending rounds.

Even though structurally different, the case study on European science advice mechanisms in fisheries (Montana, 2020) points in a similar direction. The supremacy of the Commission to define policies and to frame the general epistemological interest is not contested in this case. The mechanism is geared towards reaching consensus on the grounds of representing different opinions. Therefore, it is important that general interests are defined and negotiated in the terms of reference, providing concrete instructions for the science advice bodies, but also defining the limits of their authority (Montana, 2020: p.307). Additionally, the case study underlines that the authority and credibility of such advisory bodies also relies on "including diverse representation of experts from both different national settings, but also from a wide range of disciplinary perspectives" (Montana, 2020: p.301).
General interests must be defined and made explicit for science advice to be efficient: first, because political interests may be fought over on scientific grounds; second, because scientists themselves often pursue political goalsin the broad sense of pursuing ones own convictions about the subject matter or wanting to "make the world a better place"; and third, because scientists often cannot avoid acting on normative grounds in the way their research questions and objects are framed. While a researchers own values unconsciously (and sometimes intentionally) play into questions of methodology and research design, research questions are often designed in a way that instrumentally reflects political and societal needs. "While national political interests cannot be ignored or avoided in science diplomacy, they are just one of a number of interests that must be considered and made visible for

achieving policymaking results. The S4D4C cases reveal that a unified or unitary interest seldom exists on any level; rather, we find that there is a complex array of competing and cooperating interests of different types (political, scientific, economic, and personal) that operate on different levels and scales. [...] a challenge for science diplomacy is to find an optimal balance between cooperation and competition." (Young, 2020: p.5)

The case studies show that interests profoundly matter in science diplomacy. However, this is less the case in the broad sense of nation state interests that typological models of science diplomacy may suggest. In concrete science diplomacy constellations, national interests do not pose a challenge to international cooperation as they are generally assumed and accepted. By contrast, institutional, procedural and political interests pose tangible challenges in a more granular sense, especially with regards to creating and maintaining concrete rules and procedures.

3. Values

Science diplomacy is located at the intersection of (i) science, (ii) science, technology, innovation (STI) and higher education (HE) policy as well as (iii) foreign policy and international relations, bringing together scholars and practitioners from these policy areas. These different realms or social spheres (i-iii) are also borne by different priorities and value structures, as well as terminologies, while each has its own sense-making mechanisms and regimes of legitimacy. Within the political sphere of Europe (Manners, 2002), especially in diplomacy, values are ideally related to peace, human dignity, freedom, democracy, equality, the rule of law, human rights, pluralism, tolerance, justice, solidarity, gender equality, non-discrimination, sustainable development, and good governance; whereas values within the scientific normative sphere correspond to universalism, communality, disinterestedness, organized scepticism, responsibleness, precautionarity, openness, systemic (not purely technical) solutions, truth and originality.

These two sets of values seem to provide guidance to actors in different ways while demonstrating structural similarities and correspondence. Political and diplomatic values provide the grand objectives for science diplomacy initiatives. Peace and development as end goals of science diplomacy, for instance, are largely consensual in EU official documents as well as the interviews we conducted. Scientific values are used less in regard to framing the grand objectives of science diplomacy than to qualify and legitimize the contribution of science to the deliberations and reflections related to addressing complex problems. Given the multitude of practices at the intersection of science, STI and HE policy and foreign policy, we observe that values matter in science diplomacy because they enable actors to make sense of these intersecting practices. Values operate as a cognitive and often moral frame of their representation of the world, and as normative guidelines or reference points for their practices. This particularly relates to "global challenges" and the responsibility of science to address them together with non-scientific actors beyond national realms (Flink and Kaldewey, 2018). Values also provide legitimacy to various actors roles and positions: In a situation in which science diplomacy does not correspond to a recognized professional field or an institutionalized policy sector, relating science diplomacy practices to values is important as it contributes to providing actors with legitimacy.

In international relations, actors cannot force positions or resort to imposing sanctions on others. If collaborations are sought, actors share a minimal consensus, which presupposes a set of shared values or interests, even to the point that they might implicitly or explicitly agree to disagree. In our analysis, this matters because science diplomacy brings hitherto unexpected values to the sphere of international politics, i.e. values from the social system of science. We thus ask what these values are that science diplomacy relates to and offer sense for practitioners at this intersecting sphere. Comparing these values, we see that in some cases they actually differ from others, whereas in other cases values from science, science policy and foreign policy only appear as different but represent cross-cutting social principles. In any case, we may begin from the consensual consideration that we often find normative values in operation, i.e. actors share an implicit understanding about what is good or bad, proper or improper, and desirable or undesirable. Mutual recognition irrespective of provenance has been identified as a cross-cutting value, both in international science and international politics and as a prerequisite for conjointly addressing global societal challenges.

Based on the different notions of values outlined above, our transversal analysis shows that European support for research and innovation frequently references upholding good governance, openness, sustainable development, equality and responsibleness. In particular, the argument for 'supporting development' appears crucial to understanding several cases, e.g. EU-Africa cooperation in food security, water management, open science, the case of SESAME, and joint international programming, etc. Despite differences, science diplomacy offers an organized platform of exchange on contested values: How is research funding allocated in a transparent and 'fair' way; how do we organize selection processes when scientific expert evaluations give results that are not in line with political objectives and frameworks. The idea of being 'fair' could thus bring about different results in a more politically driven or in a more scientifically driven context.

Tracing the values dimension across our project and nine case studies, there seems to be a contrast between:

- values when talking of science diplomacy as a process and policy goal in general, when values whether political or scientific are rarely defined but easily put forward. Here, the mechanism of sense-making and legitimization, and the reference to values is quite obvious. The EUs Global Strategy 2016 provides the references to a shared vision and common action for a stronger Europe based upon interests and values (European Union, 2016). In the "Madrid Declaration on Science Diplomacy", we also stressed "the need to strengthen science diplomacy strategies and practices worldwide for the support of universal scientific and democratic values" (S4D4C, 2019a). While science diplomacy does not require shared core values, cooperation is facilitated when they are not conflicting. For example, in our case study on water diplomacy, we learn that it may be easier to agree on joint research related to water quality rather than starting from the understanding of water as a scarce and contested resource. On the other hand, the value of 'openness' has taken a prominent role with European science diplomats promoting open science, open innovation and openness to the world as well as responsible research and innovation. Values lend legitimacy to negotiations, with science diplomacy borrowing from the two worlds it combines, for example referencing both peace as well as excellence in the set-up of the research infrastructure in the Middle East, such as in the case of SESAME (Rungius, 2020).

- values when talking of science diplomacy in specific contexts and contents. As we detail below, explicit references to values are much scarcer than one may have expected. When discussing interfaces, actors rarely refer to values as we defined them above. They might share (and mention) determination, ambition, commitment, patience, endurance, curi-osity, accountability and reproduci-bility. Beyond the variety of cases, and the diverse implicit under-standings of values that may be covered, it seems that the dominant transversal value discourse that operates as a cognitive and moral frame in most cases is geared toward development. Many case studies have investigated the interactions of actors in socio-economically asymmetrical relations, be it infectious diseases (Šlosarčík et al., 2020), water management (Tomalová et al., 2020), joint international programming (Flink, 2020), SESAME (Rungius, 2020) or food safety and security (Ravinet et al., 2020). Strong Western partners thus aim to collaborate under the umbrella of official development assistance, or with lesser developed countries. Different values are thus attached to the purpose of collaborations, most of which were based on R&D funding opportunities. Science diplomacy in these contexts often qualifies as development cooperation in the field of research according to which capacities can be raised, as well as in terms of administrative procedures or professionalization of fund-raising. Some case studies speak to differences between cultures and critical negotiations, such as in joint programming situations (Flink, 2020) and in the case of open science diplomacy (Mayer, 2020).

Due to its focus on collaboration, science diplomacy has also been regarded as a tool for connecting and communicating with actors in autocratic and semi-autocratic states, or at least with those showing problematic statehood properties. This is reflected in some case studies, such as SESAME (Rungius, 2020) or joint international research programming (Flink, 2020), and here the goal of science diplomacy is to strengthen connections with the civil society in those states, not least in anticipation that their scientific leaders are also likely to seize leading positions as future policy-makers. In terms of sense-making and contributing to building a collective identity for science diplomacy actors, we notice that this value of maintaining or developing communication through science with the more or less explicit horizon of political reform is more likely to favour consensus rather than directly referencing the value of democracy or freedom. This strategy rests on the corresponding scientific norm of universalism and civic/political cosmopolitanism. Often, scientific universalism is made explicit to conceal that political reform processes in a foreign country are the actual goal, while foreign partners should not be rebuffed by that. Open science, which aims to change how science is done, is led by Europe, and the case study (Mayer, 2020) shows how this approach of opening scientific communication processes and results unfolds a soft power that promotes Europe globally as an open region that shares knowledge for the benefits of the worlds entire society.

Overall, our transversal analysis of the value dimension across the cases results in a paradoxical observation: values in science diplomacy matter because they enable actors to make sense of their practices, but in most of the case studies, values operate as sense makers indirectly. Values are important but are mainly internalized and implicit. As texts and interviews revealed few concrete references, all case authors reported in an internal survey (S4D4C, 2019b) if values were addressed during their empirical works. We found that they are present, for instance, in a fuzzy and implicit way within the discourse about development, or they may be highlighted as unmet needs, e.g. conflict is addressed and not peace. If we take the scientific value of truth, for example, the common narrative of science diplomacy suggest that it is can be used to bridge and unite partisan political perspectives. Our case studies reveal that truth is relative to what actors make of it, but it can offer some leeway in communication when it is treated as a value by all parties. It is also clear that values that are less contested, or that are more likely to be interpreted in diverse or even ambivalent ways, are preferred as focal points in most science diplomacy cases. We observe references to scientific values related to excellence, openness, innovation or impact of science, but rarely to ethics or academic freedom.

Lastly, from an analytical standpoint, it is hard to deconstruct to what extent 'scientific norms' operate in the realm of science diplomacy. Scientists and their endorsers explicitly resort to norms, e.g. those stylized by Robert K. Merton (1942), such as universalism and 'organized scepticism', has often been deconstructed as a strategy of boundary work, i.e. to demarcate science from non-science (Gieryn, 1983) and present the former as sublime, self-regulating and, therefore, uncontestable. This boundary work and demarcation strategy may not fit with the idea of science diplomacy precisely taking place at the boundary, or rather interface. In addition, scientific norms, such as organized scepticism, are usually observable in a rather idiosyncratic manner at field-specific or disciplinary levels. It is common that members of specific scientific disciplines provide the 'right to be wrong'(Fuller, 2000: p.151) to their kindred spirits, in order to keep up the flow of scientific knowledge production. Moreover, neither does universalism mean that scientific communities are open to examining any finding or argument regardless of where the finding is from. Against this backdrop, the calling upon scientific norms by advocates and endorsers of science diplomacy is a form of sense-making. An open attitude to new findings, critique and different positions is desirable for the world of diplomacy, in particular, if political particularities can be bridged.

4. Scale

Scales matter profoundly for the conceptualization of science diplomacy: they are central to framing the means (solutions) and ends (problems) of science diplomacy. Generally speaking, science diplomacy targets issues on a transnational scale (global challenges) and aspires to address these ends by means of strengthening or redesigning the interplay between scientific activity, science policy and foreign policy at potentially all governance levels (Aukes et al., 2019; Berkman, 2011; Melchor et al., 2020; Stone, 2020). In that sense, scale seems to be ubiquitous for what we think of as science diplomacy. But how does scale specifically matter for science diplomacy? How does it play a role in the individual science diplomacy cases? Can it help us make sense of science diplomacy? Looking at the case studies, scale appears to matter in various ways. In this section, we examine science diplomacy as a policymaking arena that is largely based on scale framing. Borrowing from (Van Lieshout et al., 2012; 2014) scale is regarded as a dimension that is raised to constitute a policy problem and scale framing as a "powerful mechanism in shaping the meaning of policy issues" (Van Lieshout et al., 2014: p.550), with scale being defined as the "spatial, temporal or administrative dimensions used to describe a phenomenon, and levels are the different locations on a scale" (Van Lieshout et al., 2014: p.551). This perspective builds on the understanding that policymaking is a constant struggle over ideas, and specifically, "a struggle over the criteria for classification, the boundaries of categories and the definition of ideas that guide the way people behave"(Stone, 1988: p.11 from Van Lieshout et al., 2012). Based on that understanding, scale provides an elucidating, almost heuristic perspective on science diplomacy.

Science diplomacy can be conceptualized as a matter of scale framing on the grounds of the following three dimensions: spatial, administrative and epistemic. Additionally, science diplomacy may distinguish between problem and solution framing. Science diplomacy-specific problem framing largely resorts to the spatial scale, ranging from the sub-national to the global level. The administrative scale refers to different governance levels from the organizational and national, to the supranational and the international level. The administrative scale is usually referred to in terms of science diplomacy solution framing, including calls for improved governance frameworks to tackle global scaled challenges. The administrative scale may also be addressed as part of the problem framing. This may occur when science diplomacy becomes a synonym for enacting towards changes in administrative procedures, usually towards more collaboration and knowledge-based decision-making. The epistemic scale refers to different levels of knowledge specialization: specialized epistemic communities[1], disciplinarily specialized, functionally/professionally specialized and unspecialized epistemic communities. We borrow the notion of epistemic communities as a "network of professionals with recognized expertise and competence in a particular domain" from Peter Haas (1992: p.3), though we do not confine it to expert networks exclusively concerned with science advice, but broaden it to professional communities sharing a "commitment to the application and production of knowledge" based on "shared patterns of reasoning"

[1] The epistemic scale was added to the original model representing a constitutive aspect of science diplomacy. By contrast, the temporal scale, which was originally part of the model, has been dismissed here. The temporal scale is discussed in the "rhythm and timing"section below.

(Haas, 1992: p.3). This includes diplomats and scientists. The insufficiency of 'standard science´ (Gibbons et al., 1994) and traditional diplomacy to tackle global challenges is a principal and characteristic claim of science diplomacy (Aukes et al., 2019: p.9). It is central to the problem framing behind science diplomacy, which depicts the formal separation, institutional disconnection and functional differentiation of the two professional communities – scientists and diplomats – as a fundamentally epistemic problem:

"The complexity of grand societal challenges requires a deep understanding of the scientific dimension as well as the geopolitical dimension of the issue at hand. It requires both 'transformative science' and a 'knowledge-based' diplomacy. It is probable that neither of the communities can solve the challenges we face on their own" (Aukes et al., 2019: p.9).

This epistemic problem framing is reflected on the administrative scale by identifying a lack of coordination between science and foreign ministries, and the EU between EEAS and science and innovation related Director Generals (DGs) respectively.

In terms of solution framing, the most prominent declaration brought forth in the name of science diplomacy, The Madrid Declaration on Science Diplomacy, calls to better integrate science into foreign policy on all governance levels (S4D4C, 2019a). Yet, behind this claim stands another epistemic scale framing: It is the claim that academia, with its highly specialized organization of research (into scientific disciplines), is ill-suited to grasping and responding to the genuine complexity of grand societal challenges (Aukes et al., 2019). Science must be open to the inclusion of different perspectives and experiences of stakeholders from outside academia. Science advice, effective knowledge transfer and the "necessity of collaboration between the diplomatic, scientific and policy community" (Aukes et al., 2019: p.6) are another set of remedies suggested by science diplomacy that locate the problem/solution framing on the epistemic scale. Finally, science diplomacy frames global challenges as a problem of collective action between nation states. The transnational nature of global challenges is framed on the level of international actors (administrative scale) as a problem of nationalism and protectionism, lacking international cooperation, trust and willingness to act in shared interest by state decision-makers (Melchor et al., 2020; S4D4Ca, 2019).

The case studies on infectious diseases and on water diplomacy highlight this point. Viruses transcend national borders and pose an even greater threat in a highly interconnected and globalized world, which merits concerted efforts: "The fight against infectious diseases has frequently outreached national borders and provided a platform for deepening of international cooperation as well as for the formation of global governance in the field of medicine" (Šlosarík et al., 2020: p.7). The problem is spatially located at the global level, while the solution logic to this problem is located on the administrative scale, calling for better governance on all levels. The case study on infectious diseases reveals a wide variety of policy actors and legislative frameworks that are part of public health strategies and that address fighting infectious diseases on national, EU and international levels with the World Health Organisation (WHO), the Global Research Collaboration for Infectious Disease Preparedness (GloPID-R) and Global Health Security Initiative (GHSI).

At the same time, while the administrative scale generally serves as a solution frame, the case studies also reveal scale related difficulties that are becoming relevant in terms of proposed solution framing, with the number of actors and administrative levels increasing. The study lists ten different government and government-related actors for global health in the UK alone, including ministries, research organizations and research funding organizations (9 for Germany, 8 for the Czech Republic), with a similarly diverse landscape at the EU level and internationally. Science diplomacy rhetoric often seeks to raise awareness for more cooperation and inclusion of all actors in a policy field on the basis of an administrative scale logic. However, this does not provide a clear approach to a solution. The case study on infectious diseases identifies an "institutional mix" and claims that "a preferential institutional pattern cannot be identified. Instead, the reaction resembles an evolving nebulous structure" (Šlosarík et al., 2020: p.25).

A similar multitude of stakeholders, policy agendas and understandings was identified in the water diplomacy case (Tomalová et al., 2020) and in the food case (Ravinet et al., 2020). While the perspective of science diplomacy highlights the importance of various relevant stakeholders to interact more closely due to its scale-based problem framing, the difficulty of specific suggestions or prescriptions apart from a general call for more cooperation in light of the identified complexities becomes apparent. This difficulty seems itself to be scale related; the more science diplomacy is understood as a matter of inclusion and bridging actors from all administrative levels, the more the original distinction between levels is questioned and would have to be re-organised. In light of the various understanding of policy areas, multiple de facto governance practices and nation specific approaches identified within each country, whether or not policy recommendations can be "scaled-up", both spatially and administratively, within and across different topics in the name of science diplomacy is questionable.

In terms of problem framing, science diplomacy strongly relates to a spatial and epistemic scale. To a lesser extent, this is also the case for the administrative scale. In terms of solution framing, science diplomacy relates largely to the administrative and the epistemic scale. In that sense, science diplomacy is a matter of inferring the spatial and the epistemic with the administrative scale. As a result, science diplomacy points to a number of problem constellations while highlighting the complexity of the interactions involved. With regards to scale, we may draw from the cases that "consistency and boundaries of 'science diplomacy' shouldnt be overstated because of remaining vague and unclear" (Ravinet et al., 2020: p.112). This should not only be viewed as a weakness. Rather, it is a result of the complex, scale-based problem framing behind science diplomacy. At the same time, the specific scale-framing logic of science diplomacy allows us to perceive the "raising concerns over global challenges in science funding", "the emergence of the dedicated science diplomat role" (Ravinet et al., 2020: p.112), the institutionalization of science advice mechanisms, joint programming or the setting up of large research infrastructures as elements of one theme.

5. Levels

Levels matter for science diplomacy because they are key in structuring our understanding of how different actors and stakeholders can jointly respond to global challenges. This section digs deeper into one of the three elements (spatial, temporal, and administrative) that are studied in the scale matter. It serves as a close up examination into the spatial scale and how levels of international governance determine policy problem framing (Van Lieshout et al., 2014: p.551). Levels are critical elements in understanding how policy problems and science diplomacy responses to problems are formulated depending on which level a problem is addressed. Therefore, we introduced a proposed framework of four levels based on science diplomacy activities, i.e. (1) global, (2) sub-global, (3) national, and (4) sub-national levels. Moreover, two sub-levels – sub-global and sub-national – consist of several dimensions depending on the stakeholders involved and the relations among them, which lead us to distinguish three dimensions within sub-levels: (1) bilateral, (2) multilateral, and (3) regional.

First, we explain what we understand by these individual levels and dimensions: The global level is perceived as a platform coordinating science diplomacy activities of actors concerned with matters of global scale such as the WHO, the United Nations (UN) but also non-governmental stakeholders, such as private companies and civil society. Sub-global level activities address less extensive cross-boundary issues, though the activities fall within the worldwide narrative of global problems, driven by physical and/or human elements of geography (see more in the geography matter). National level activities are primarily driven by governmental actors to protect citizens, but non-governmental stakeholders may be involved as well. The sub-national level consists of all activities underneath the national level involving local stakeholders, such as cities or sub-national regions. As for the dimensions, the bilateral dimension contains the cooperation of two stakeholders based on elements of physical or/and human geography; the multilateral dimension is perceived as a category consisting of cooperation among more than two actors based on human geographical aspects; and the regional dimension encompasses cooperation among more than two stakeholders building either on physical geography or on both physical and human aspects of geography.

Science diplomacy processes naturally pervade all levels. Similarly, stakeholders are involved in various levels parallelly. Therefore, science diplomacy is usually a matter of mixed levels and mixed dimensions[2]. This reflects the complexity of science diplomacy processes that are needed for an effective response to global challenges. In most cases, a stakeholder is involved in several organizations and has established cooperation with a variety of actors, producing a complex network of science diplomacy ties, cooperation and actions on multiple levels and dimensions. This results in many mixed categories of science diplomacy that combine different levels and dimensions.

The global level serves as a stage for the identification and definition of global challenges, e.g. WHO in determining infectious diseases or the Food and Agriculture Organization (FAO) in delineating

[2] Since dimensions are lower categories than level, we understand the mixed-level science diplomacy as the term.

food security as a problem on the worldwide scale (Ravinet et al., 2020). Therefore, the global level provides the broadest policy problem-framing involving a wide range of stakeholders, which adds to the complexity. The sub-global level encompasses all crossboundary activities driven by physical and/or human elements of geography. Sub-global science diplomatic cooperation stems from two principal issues. There is a need for tackling cross-boundary issues that are part of the worldwide definition of global problems. Further, concrete cross-boundary problems influence policy problem-framing that comes from global-level understanding, but it is more specific, e.g. bilateral collaboration over water supplies from Israel to Jordan as a part of the globally acknowledged problem of water security. In this respect, physical geography is the main driver of bilateral or regional dimensions as geographically close actors face similar challenges. It is worth mentioning here that there is advanced regional collaboration in science diplomacy over water issues that are shaped around river basins, e.g. the Mekong River Commission unifying riparian states to coordinate environmental protection and water security (Jacobs, 2002) or the Convention on Cooperation for the Protection and Sustainable Use of the Danube River (ICPDR, 1998).

Secondly, science diplomacy at the sub-global level is a potential way to strengthen scientific capabilities through knowledge sharing and therefore, jointly advance ideas that address global challenges. This is demonstrated, for example, in bilateral cooperation between France-Germany and Israel-USA in cyber security and infectious diseases prevention (Kadlecová et al., 2020; Šlosarík et al., 2020), France-Japan in cyber security research, and a science diplomacy facilitated partnership between Masaryk University in Brno (Czech Republic) and Georgetown University (USA) in the same field (Kadlecová et al., 2020). In this regard, not only physical geography but also human geography, affect science cooperation on the sub-global level based on the cultural and/or historical relationships among stakeholders.

It is worth highlighting the case of the EU, which represents a model of sub-global science diplomacy with its commitment to contribute to tackling global challenges, such as infectious diseases or food, water, and cyber security. Not only does the EU operate within its borders, e.g. establishing European Centre for Disease Prevention and Control (ECDC) or European Union Agency for Cybersecurity (ENISA), but also outside of the EU, as for example in the Partnership for Research and Innovation in the Mediterranean Area (PRIMA[3]). The EU is thus engaged within the broader region, the Mediterranean, rather than only the region of the EU per se. The regional dimension of science diplomacy can also be perceived as a tool for enhancing the actors role in responding to global challenges. This motivation may extend beyond regional collaboration and lead to so-called inter-regional cooperation, e.g. Central Asian Regional Water Stakeholder´s Platform (WASP) or joint research collaboration in food security of the EU and the African Union (AU) (Ravinet et al., 2020; Tomalová et al., 2020).

The national level oftentimes refers to policy problem-framing from the global level butfocuses on aspects relevant for a country within its legal and regulatory space as well as its foreign affairs. Therefore, states undertake science diplomacy activities

[3] PRIMA is a joint science diplomatic program searching for a scientific and technological solution on water scarcity and agriculture sustainability in the Mediterranean region.

jointly with non-governmental institutions to establish solid knowledge in the prioritized area in order to ensure the security[4] of its citizens. For example, in the case of the COVID-19 outbreak, the priority of states was to protect citizens and stabilize the situation within national borders; however, in addition to ensuring security, countries also advanced know-how on other levels - especially upper ones, and therefore contributed to addressing the challenge on a global scale. For example, the Czech Republic stressed in its National Cyber Security Strategy for the period 2015 to 2020 the will to "play a leading role in the cyber security field within its region and in Europe" (NSA, NCSC, 2015: p.7). Thus, the National Cyber and Information Security Agency (NCISA) was established, and cyber attachés were deployed to the US, Belgium, and Israel while cooperation in research within the EU and the North Atlantic Treaty Organization (NATO) was reinforced (Kadlecová et al., 2020). Similarly, Germany and the United Kingdom used national scientific knowledge, including governmental and private research capacities, to firstly ensure citizens security in the field of public health, and, secondly, to contribute to international activities during the Zika outbreak in 2015-2016 (Šlosarík et al., 2020). While the national level prioritizes citizen protection in the face of challenges, the ambition to become an important player by advancing knowledge on the sub-global and global level is no less important a driver of state science diplomacy engagement.

The sub-national level contains all activities underneath the national level as determined by geographical elements. As mentioned above, science diplomacy activities may include bilateral, multilateral, and regional dimensions based on the type of stakeholders and the relationships among them. Dimensions of the sub-national level acquire the same features as those of sub-global levels, but they unite different stakeholders, such as cities, research institutions and sub-national regions.

Even though global, sub-global, national, and sub-national levels are understood as building blocks for the science diplomacy process aimed towards addressing global challenges, these categories oftentimes overlap, and therefore many examples of mixed-dimensions science diplomacy can be found. For example, the EU-India Water Forum or China-EU Water Platform comprise both regional and bilateral dimensions of the sub-global level. The EU is considered a sub-global level actor, while concomitantly, EU Member States are nationally involved in bilateral or multilateral cooperation based on their expertise in the field and on historical ties (Tomalová et al., 2020). Similarly, EU-US or EU-Japan cyber relations can be added to this mixed category (Kadlecová et al., 2020).

Moreover, one stakeholder can simultaneously operate in multiple dimensions and on multiple levels of international cooperation that follow the actors priorities, expertise, and privileged relations in science diplomacy. To illustrate this phenomenon, the German government coordinates research in public health on the national level in cooperation with the private and non-governmental sectors. Germany is also actively involved in global health protection in numerous regional institutions, e.g. G7, G20, EU. Finally, Germany is vigorously engaged within the framework of the GloPID-R and the WHO (Šlosarík et al., 2020) on a global level. These simultaneously overlapping memberships

[4] Security is understood in a broad sense referring to the concept of human security. In the context of this study, security includes elements of water and food security, public health etc.

and activities vary along with situationally defined interests, expertise in the field, and human and physical geography.

To sum up, we have identified four levels of the science diplomacy process; global, subglobal, national, and sub-national. Additionally, sub-levels are divided based on the number of actors and type of stakeholder relations to three dimensions; bilateral, multilateral, and regional. Nevertheless, science diplomacy actors rarely participate on only one level or dimension; more often, they are simultaneously involved in multiple levels and dimensions, cooperating with a wide range of distinct actors. Indeed, only agglomerating activities throughout levels offers the potential to address challenges comprehensively. Therefore, tackling global challenges through science diplomacy will only be effective if approached as a "mixedlevel" effort.

6. Individuals

Science diplomacy is often conceptualized across-the-board as the intersection of science and diplomacy. In some cases this intersection can be viewed as an interaction between a wide variety of different professional communities of scientists and diplomats. However, the relevance of individuals within these professional communities carrying out activities that we broadly summarize as science diplomacy is rarely discussed. In our case studies, we found that individuals 'matter' profoundly for science diplomacy as creative and responsible actors within their respective professional realms, despite the fact that not all of them are explicitly identified as 'science diplomats'.

Science diplomacy is not well defined in terms of job descriptions. This is partly due to the novelty and conceptual breadth of the concept. The term science diplomacy does not come with clear-cut understandings of related tasks, responsibilities and strategies. There are no manuals on how to 'do science diplomacy'. Science diplomacy trainings and seminars are nascent but evolving[5]. Furthermore, the need for science diplomacy has not translated into distinct professional identities to date (Degelsegger-Márquez et al., 2019). In addition to this, few governments have systematically implemented policies in the sense of tailoring science diplomacy positions and responsibilities, for instance, dispatching science attachés (Flink and Schreiterer, 2010) or other field expert delegates abroad, like the case regarding cyber attachés (Kadlecová et al., 2020) or water envoys (Tomalová et al., 2020). Since there are few role models to which one may relate, working "at the intersection of science and diplomacy" often requires individuals to define their roles, tasks and professional identities themselves. It is therefore incumbent on the individual to frame science diplomacy issues and bundle a wide variety of previously unrelated resources. In this way, individuals play an integral role in science diplomacy.

As the interaction between scientists and diplomats are not often formalized or institutionalized, personal networks, previous positions and affiliations and interests of respective persons all play a crucial role. The case studies highlight that the impact of science diplomacy depends strongly on how individuals promote these efforts. For instance, in the case of cyber security, "all of the national cases show that the relationship between diplomats and scientists remains quite narrow and involves very few actors. Their relationships are often informal and very weakly institutionalised. This inevitably leads to the conclusion that in most cases, cooperation very much depends on the personal interests and previous experience of those in charge, who are able to determine their own approach to diplomacy and undertake particular activities independently" (Kadlecová et al., 2020). The cases on food security and joint programming provide other examples of the significance of individual ability (and eagerness) of officials, especially to serve as brokers, mediators or interlocutors, all of which are roles and duties that require tact, discretion and involvement, rather than being a matter of technical execution (Ravinet et al., 2020; Flink, 2020). In that regard, individuals soft skills, such as communication, negotiation, and capacity to build trust, are reported to be of high

[5]. See for example: https://www.s4d4c.eu/european-science-diplomacy-online-course/

importance (Degelsegger-Márquez et al., 2019).

As a result, science diplomacy builds on the creativity, initiative, advocacy, abilities, networks, priorities and professional identification of the individuals involved. Certainly, this sort of bureaucratic discretion (Rourke, 1984) applies not only to science diplomats but also to all senior service positions in public administration and diplomatic missions. Within legal confines, officials have unfettered freedom of action in how they understand, implement, or execute policies. However, with regards to the matter of science diplomacy, the role of the individual agent in this field may be required to transcend traditional confines related to job creativity, becoming proactive in their role (Young et al., 2020). Identifying those who perform science diplomacy in their daily jobs may be a matter of personal perspective. Some actors choose to identify pro-actively as science diplomats, thereby creating new forms of political intervention (Gluckman et al., 2017), while others act in what many would consider to be a science diplomacy interface without ever using the term. In this respect, the variability of science diplomacy sometimes works to an individuals' advantage: the fact that science diplomacy is so variable makes individuals' capabilities of framing science diplomacy for all sorts of interests very useful. Proficiency in manoeuvring within this ill-defined space becomes a very important ability.

As part of this set of individual abilities, another feature that stands out in the deployment of science diplomacy is innovation and leadership. Leadership is required to overcome administrative, financial, and cultural barriers. Science diplomacy transcends the understanding of traditional domains not only on a conceptual level but, if translated into concrete policies, it usually requests collective efforts across departments, sometimes cutting through ministerial domains, working cultures, hierarchies, and budget lines. This again requires steady and firm political leadership. In our case studies, the importance of political leadership is apparent in joint research programming, in light of the fact that "bilateral initiatives are launched in the course of high-level meetings between ministers or state secretaries" who express their intention for their countries to strengthen collaborations (Flink, 2020). Additionally, the role of individuals who show strong political leadership is highlighted in the cyber security case, with the first deployment of science diplomats in the history of the Czech Republic under the Deputy Prime Minister for Science, Research and Innovation, Pavel Belobrádek (Kadlecová et al., 2020).

At the same time, the effect of individuals in science diplomacy often builds on institutional affiliations and traditional professional identities. The evolution of many science diplomacy cases do not follow standardized procedures or roadmaps. They evolve in unforeseen and unique ways, and some are brought forth by the initiative and intuition of a few individuals using their reputation and networks. SESAME is a case in point that owes a lot to the commitment of individuals (Rungius, 2020). It also profited largely from the institutional affiliations and the institutional backing of those involved. The synchrotron was largely instigated and pushed by retired directors of European Organization for Nuclear Research (CERN), who later took on the position as directors of the SESAME Council. In addition to their expertise, they have contributed reputation and credibility that helped to elevate the projects critical standing vis-à-vis the project partners/national and international institutions. At the same time, institutions and professional structures must also create space for agency in terms of science diplomacy. Therefore, when we say that individuals matter for science diplomacy, this is only true in relation to the structural and institutional affiliations upon which agents are allowed to act and on which they may transform and shape existing boundaries.

Assessing the role of individuals has implications also for the conceptualization of science diplomacy. Science diplomacy tends to be understood as a matter of interfaces between science and diplomacy, and therefore between at least two representatives of the respective communities; however, 'interfacing' may also occur within one person. This often overlooked aspect refers to those situations in which one person wears two different hats simultaneously within one function or affiliation. It may seem unexceptional that a physicist negotiates for public funding or for the support of nation states in an international arena to establish a synchrotron (Rungius, 2020), or that a ministry official has a say in determining academic review procedures and sets procedural standards in funding joint binational research activities (Flink, 2020). But at a closer look, these configurations prove to be the crucial piece that brings forth a bigger picture of science diplomacy.

The science diplomacy debate challenges traditional understandings of professional profiles and career paths in the interaction of science, diplomacy and policy. At a minimum, assessing how individuals matter for science diplomacy adds a new perspective on 'professional hybrids' which may have previously existed but not been acknowledged or given terminological consideration. It may also allow for new perspectives on the configuration of professions and professional duties. Science diplomacy constitutes an undefined professional arena, in which individuals must choose how they want to constitute, shape, and take on responsibilities, and how they take up duties, carve out responsibilities, play out formal positions and institutional affiliations, and are able to build exchanges and professional collaborations. Therefore, individuals matter as far as science diplomacy builds in practice on their personal initiative, advocacy, creativity, abilities, networks, priorities and prof-essional identification.

7. Geography

Our S4D4C empirical case studies argue that geography continues to be influential regarding how nation states approach diplomacy in general and science diplomacy in particular. The concept of science diplomacy emphasizes factors such as scientific, technology and innovative capacity of a country when determining its overall power, next to economic power, competitiveness or education. As a consequence, the relevance of geography (or population, raw materials, etc.) as a defining factor in international affairs has declined in relation to these other elements (Nye, 1990). Yet geography does play a role. First, physical geography has an impact on the needs of any country and, by extension, geographical regions. Countries or regions may be located in mainland or coastal lands, upstream or downstream a river, in a flat or mountainous area, etc. which will determine in part their access to natural resources, such as water, food or fish, among others. Consequently, over time, these countries or regions have developed certain expertise to address their access to these resources or be part of related negotiations, which ultimately leads to technological innovation and economic growth. Second, human geography matters because of the extent of cultural, scientific, historical or bilateral relationships either facilitate or hamper collaborations, influence mobility patterns, and shape institutional arrangements. Taken altogether, we argue that geography matters in science diplomacy.

The S4D4C case study about water management directly exemplifies how the Netherlands, and to a lesser degree the UK, has positioned itself as a global expert in water management and water diplomacy due to purely physical geographical elements (Tomalová et al., 2020). The Netherlands is globally considered a reliable partner for water-related projects on all levels (sub-national, national, sub-global, global) largely due to its long cultural, scientific and technical experience with rising sea levels and floods. This expertise has propelled a complex public institutional framework with strong public policies related to water, leadership in coalitions of countries and diplomatic positions (the Water Envoy), and a richness in environmental consultancies, water technology companies, and non-profit organisations that operate transnationally. The case study also provided insight into how geographical locations may drive the use of water as well as related interactions between science and diplomacy in Central Asia.

The case study about food security (Ravinet et al., 2020), underlines how regions with poor physical geographical conditions, characterised by deprived-nutrient soils and/or severe droughts, have shaped priorities in the African Union and the European Union as part of their agriculture diplomacy. In doing so, a complex variety of policy and funding instruments have been deployed for international scientific and technological collaborations to find solutions for food security and availability issues in those regions. For instance, the Partnership for Research and Innovation in the Mediterranean Area (PRIMA) funding initiative between countries in the North and South of the Mediterranean region fosters collaborative research surrounding issues related to water and food availability, agriculture, soil, etc.

The case study about fisheries management (Montana, 2020) also highlights how an element from physical geography such as easy access of a country to open waters, and therefore fish stocks or fisheries influences its science diplomacy actions. Again, this physical geographical factor shapes expertise and complex institutional frameworks: for instance, science advice mechanisms that operate among different scientific and political communities. These mechanisms prove to be important for a country when negotiating with others for fishing quotas and regulating fishing efforts (Montana, 2020).

Based on these case studies, physical geography elements such as being mainland or coastal land, flat or mountainous lands, access to rivers or sea, richness in natural resources, and other elements have led to societal pressure over centuries. The development of innovative technologies to tackle these geographical hurdles or make the most out of them has pushed growth and prosperity. Physical geography has an impact on the level of development, growth and prosperity of countries, partially shaping professional expertise in certain fields, as well as complex public institutional frameworks, and the development of private industry and technological competitiveness (Gallup et al., 1999; Henderson, et al., 2001; Hibbs and Olsson, 2004). Physical geography thus matters in science diplomacy because of the scientific and technological expertise developed as a direct consequence of physical geographical factors. Physical geography can be harnessed as a soft-power element of a country (in the international system), to position itself as the leading country in the field, promoting its own industry worldwide and fostering global alliances with countries with the same needs.

On the other hand, human geography understood as the series of cultural and historical linkages that brings together different countries and culturesgoes beyond physical geography. For instance, the Commonwealth brings together countries that are geographically distant apart, and so it happens with all the historical linkages between Spain and Portugal with Latin American. In our empirical case study analyses, this human geography dimension has played a particular role in the spreading pattern of infectious disease, which preferentially links countries with strong trade, business, and bilateral tourism relationships (Šlosarík et al., 2020). Additionally, research may foster scientific collaboration between physically distant countries, which may incorporate divisions of scientific labour advantageously. For example, scientists from Germany or the UK who are active in investigating Zika may provide appropriate technology to advance research, while Brazilian scientists would have the local knowledge and natural resources required to do the tests. Diplomatic approaches play a role in negotiations related to the exploitation and ownership of results stemming from these partnerships.

Lastly, analysing cooperation initiatives in a region with histories of conflict, the SESAME case study examining the joint research infrastructure the Middle East (Rungius, 2020) as well as the case focused on joint programming initiatives (Flink, 2020), show a further aspect of the influence of human geography and the challenges and limitations of 'science for peace'. The purpose of building scientific linkages between different cultures was depicted in the 'science for diplomacy' dimension from the Royal Society-AAAS (2010) taxonomy. In these instances, human geography matters in the sense of poor quality relationships (conflicts driven by religion, politics, national borders, access to resources, etc.) influencing the initial condition upon which science diplomacy approaches are conceived and/or implemented. Human geography matters because it influences the interdependence of different stakeholders.

In conclusion, transversal analysis of our S4D4C case studies demonstrates an underlying influence of geography in science diplomacy. Physical geography matters because it has shaped national needs that have fostered scientific and technical expertise, as well as complex institutional arrangements and industry development over time, which may be exploited as national soft-power assets (in international relations). Meanwhile, human geography may increase or decrease interdependence, the need for negotiations and the likelihood of shared challenges between regions/ countries, which influence general diplomatic approaches and the scope of science diplomacy.

8. Governance systems

Governance systems are like policy fingerprints; each domain involves a unique configuration of actors, stakeholders, processes, instruments, and institutions. Governance systems are both planned and emergent, and they matter to science diplomacy because they organize how foreign and domain-specific policy address grand societal challenges in concert. They may emerge as the sum of dispersed governance activities or are intentionally constructed as a targeted response to address a specific challenge. In both cases, many governance levels tend to be involved in science diplomacy sometimes exclusively and sometimes in cooperation. The comprehensiveness of the governance system in place to address a given challenge conveys the degree of confidence that there is that something can be done about that challenge. In this section, we examine governance systems across the S4D4C case studies that demonstrate these domain spanning characteristics, in particular, the environment (food security, water diplomacy), health (infectious diseases), technology (cyber security) and science policy (Open Science diplomacy, international joint research programming).

For that purpose, we look at the broader picture of the various governance systems and seek to identify three types of nodality that affect science diplomacy. Christopher Hood and Helen Margetts introduce this term to public policy in the context of a cybernetic systems-based model for understanding the tools of government. For them, the term nodality refers to the property of being in the middle of a network (Hood and Margetts, 2007), and it provides the government with the ability to traffic in information (ibid, p.6). In our analysis of governance systems, we are interested not so much in how the government uses nodality as an information tool, but how the nodality of different parts of the governance system affects its overall configuration. Drawing on network analysis (Borgatti, 2005) in a qualitative manner, we think about nodality in terms of different types of centrality, such as the amount and the quality or importance of the connections present. In other words, the more central a part is in the system, the more influential it is. Hence, imagining governance systems as networks, the concept of nodality allows us to consider the importance of system parts from a structural perspective. We focus on three nodalities to help us better understand the dynamics of governance systems:

1. Nodality of science: how central is science in the system vis-à-vis diplomacy?
2. Nodality of level: how central are specific levels of governance vis-à-vis others?
3. Clustering of nodes: which actors or institutions cluster together, and are they part of the core or the periphery of the system?

Nodality of science

Science nodes are actors, stakeholders, instruments or institutions that deal with science-based policy substances. Governance systems may involve various science-based policy substances, such as stimulating transformations in systems of knowledge production (e.g., Open Science, international joint research programming) or exchanging domain-specific knowledge (e.g., water diplomacy). There are also politics-based policy substances that involve science nodes, e.g., the preservation of national interests in the fields of cyber security, food security, or infectious diseases. In general, some policy domains in the science diplomacy component are stronger than in others. These include cyber security and international joint research programming. In other domains, the diplomacy aspect plays a secondary role vis-à-vis the domain aspect. Furthermore, some domains are situated on the intersection between science diplomacy and international development, such as infectious diseases or water diplomacy. To date, food security is still weakly linked to European foreign policy. This overview demonstrates that science diplomacy efforts are undertaken in various traditionally national policy domains, though to different degrees.

Governance systems will be organized differently depending on the prioritization of issues on the policy agenda. For example, the recognition of cyber-attacks as a high priority issue in some countries has spurred the organization of a dedicated governance system with international ambitions. In other words, the nodality of system parts may change depending on reprioritizations in the policy agenda. It also means that governance systems of relevance for science diplomacy may not be present in all cases. The position of policy domains on the science diplomacy agenda ranges from very low to high in the cases. When a policy domain is low on the agenda, this may have to do with the fact that there is little diplomatic room to manoeuvre or it has not yet become a relevant foreign policy topic. The former is illustrated by the food security domain which can rather be characterized as a basic need and demand for a well-functioning food supply system that should not be jeopardized. Open science illustrates a policy issue in the science policy domain that is high on the international science policy agenda, but that has not yet risen on the foreign policy agenda. Intermediary or mixed policy domain prioritization can be observed in cyber security, water diplomacy and international joint research programming due to various reasons. For instance, prioritization of water diplomacy ranges from a strategic policy domain, including proactive promotion of expertise through a broad array of programs for international water governance knowledge exchange (the Netherlands), to a lack of a national water diplomacy strategy (Czech Republic). Only infectious diseases are to be found relatively high on the international policy agenda, not only recently due to the COVID-19 pandemic, but also as a continuous field of attention. Whether this relates to basic health provision or dealing with crises often depends on the local context.

Nodality of level

In many cases, domain-specific governance systems pertaining to science diplomacy start from the national level. This is not surprising as many domains covered in the cases, e.g., environment, health, technology and science, are traditionally national responsibilities. International joint research programming is a typically national endeavour one for which structural processes are fragmented. A structural process that has been in place at the European level, the European Research Area networks (ERA-Nets), have had some success of institutionalizing this domain, but is dependent on EU funding to exist. Survival of ERA-Net-induced international relations after EU funding ceased have been reported, but are not the norm. For cyber security, food security and water diplomacy, we also find sub-global structural processes in place at the European level. A case in point is the Water Supply and Sanitation Technology Platform or in the food domain the High-Level Policy Dialogue on Science, Technology and Innovation. Water management aspects covered by sub-global European processes seem limited to technology transfer, which is merely a small share of what water management encompasses. As previously mentioned, national and sub-global structural processes and mechanisms in the field of Open Science are limited to the domain of science policy. Processes in that field crossing the boundary into foreign policy, which would also make them relevant for science diplomacy, are scarce to date. The most elaborate international institutional frameworks to be found in our case studies, where they clearly feature foreign policy objectives, exist in the fields of food security and infectious diseases. Especially in the latter domain, the framework is robust and tightly-knit. International and supranational systems dominate the domain of infectious diseases. Bilateral relations in this field are not prominent. National systems link up immediately to multilateral ones. It involves international NGOs such as the World Health Organization, national governments and research organizations, e.g., the Global Research Collaboration for Infectious Disease Preparedness. In food security, the international governance system includes intensive bilateral and multilateral relations between the EU, the UN and (countries from) the AU.

The capacities and capabilities supporting governance systems are very diverse and scattered across levels. Once again, food security and infectious diseases stand out as policy domains in which there are ample capacities on all governance levels. In other policy domains, the capacities dedicated to science diplomacy are very much dependent on the country and specifically in the case of cyber security the relative novelty of the domain. The character of national capacities and capabilities in cyber issues may include, but is not limited to, the presence of hightech sectors, such as ICT, whether the country has faced cyber-attacks, or whether there is sufficient budget to be redirected to this domain. In the domains of water diplomacy and international joint research programming, similar patterns are to be found. The odd one out is Open Science, where many countries have capacities in science policy specifically, e.g. (inter-)nationally operating research funding organizations, but not interpreting this as a foreign policy issue.

Clustering of nodes

In most cases, similar actor configurations can be found. Oftentimes, domain ministries or their executive agencies formulate the national policy position, including possible implications for foreign policy. They supervise sub-national domain organizations, agencies or institutes, such as national or sub-national health agencies, and in return receive science advice from them. Domain ministries are often also the point of contact and communication with actors on the international stage, in some cases coordinated by or even cooperating with the ministry of foreign affairs. Depending on the historical importance of the domain in the respective country or agreements/treaties about subsidiarity when it comes to the EU and current agenda setting, domains may be declared priority domains. Given the globalized and networked world we live in, this prioritization often entails (or perhaps must entail) ambitions on the international stage. Policy priorities then turn into overall strategies and may initiate a process of (trans-)national system establishment. Depending on bilateral or multilateral ambitions, such systems may then consist of domain ministries, the foreign affairs ministry, dedicated EU institutions, dedicated international organizations, NGOs and include mechanisms geared towards aligning positions and monitoring or reviewing scientific research in the domain. The latter then relies on domain-specific systems. For example, in the case of infectious diseases, this may involve medical information systems (cf. COVID-19).

We have sought to demonstrate that governance systems matter for science diplomacy by describing the nodality of science and levels as well as how nodes are clustered in them. The nodality of science in various systems needs to be considered in relation to the nodality of levels. Apart from an equally central importance of both aspects in some situations, the nodality of one comes at the expense of the other. In terms of policy substances and positions on the science diplomacy agenda, this entails the tension between dealing with a global challenge as a political or as a scientific problem. Science diplomacy, then, is about finding the right balance of these in different stages of addressing global challenges. Nodality of level depends, on the one hand, on the perceived locus of the challenge to be addressed. On the other hand, it depends on which level there are effective actions to be taken. For example, international food supply chains or the high risk of globally fast-spreading infectious diseases makes these domains prototypical for strongly institutionalized governance systems on the international level. Other issues, such as cyber security, for now remain situated on the national level due to aspects detailed above. Hence, the notion of nodality offers a different way of looking at the state of and trade-offs within governance systems pertaining to science diplomacy.

9. Instruments

Examining instruments is important as they are part of, and therefore shape, any policy field. Science diplomacy also relies on a set of instruments to achieve its objectives. In this section, we use the typology developed by Van Langenhove (2017) to explore the relationships that shape instruments and how they interact with each other based on our case research. This analysis moves beyond identifying what instruments are used and investigates how their interaction, or lack thereof, matters for science diplomacy. An integral part of the S4D4C mission is to identify gaps, frictions, bottlenecks and ruptures that hamper the development of science diplomacy practices. Two types of bottlenecks have been identified. First, ruptures occur when there is a gap or missing type of instrument within a science diplomacy practice or process. These occur when the mix of instruments is disjointed, shows a rupture or is insufficiently coordinated. Second, frictions arise during the development of instruments due to a lack of consistency between the objectives of different actors and institutions. This results in sub-optimal outcomes. From the case studies, we identify several examples that illustrate these problems.

Instruments of science diplomacy have been defined by Van Langenhove as those "that can be used in promoting or supporting science diplomacy" (2017: p.12). His typology is used in this section as a guiding tool to investigate science diplomacy instruments. For Van Langenhove (ibid), science diplomacy instruments may be classified into three types: strategic, operational and support. Strategic instruments are policies which set objectives, describe how something is going to be done and who is responsible for it. They often set the scope and strategic goals for the policy realm. In our cases studies, most governing institutions develop their own strategies or action plans. Those strategies rarely mention science diplomacy as an overarching goal or way to an end. Nonetheless, they may state objectives in line with science diplomacy, such as setting up international research cooperation schemes and fostering international cooperation using scientific exchange. Strategies are important as they define the policy field. They are supported by operational instruments. Operational instruments enable concrete action in a field and enact strategic objectives. They organize mechanisms of action and resource management (Van Langenhove, 2017: p.13). These may be summits, bilateral and multilateral agreements, science attachés, research programmes and funding schemes. Once again, those have been identified in all of our case studies. The third category encompasses support instruments, defined by Van Langenhove as instruments "that aim to promote or facilitate Science Diplomacy activities" (2017: p.13). Those comprise any form of dialogue and trainings involving scientists and diplomats. In the case studies, networking activities are sometimes used as they enable co-creation and international information exchange. They may take the shape of meetings and conferences, trade fairs, personal meetings between scientists and policymakers, briefings and explanatory meetings and roundtables.

In the case studies, we found evidence of the presence of each type of instrument. However, ruptures and frictions have also been identified which impede science diplomacy practices. They appear in different forms, as illustrated by the examples provided below.

Misalignment between support instruments and operational instruments are one source of rupture. This is apparent in the water diplomacy case (Tomalová et al., 2020). Czech scientists have been active in the cross-border transfer of their knowledge on water sanitation and in educational activities with developing countries. However, the broader reach of these types of activities is hindered by the lack of integration and coordination between development assistance, requiring scientists to apply for funding on a case by case basis. Here, support instruments are not met sufficiently with an operational structure. Such a scenario is common in several case studies. In other instances, non-coordination arises from the lack of strategic instruments which would enable operational activities to operate smoothly. In the cyber security case (Kadlecová et al., 2020), the lack of clear strategic instruments linking together science diplomacy and cyber security impedes the division of work between the German cyber attachés and their science diplomat counterparts (Kadlecová et al., 2020). While there is an overlap between the two positions, the lack of formal recognition of that overlap means that the extent to which cyber and science attachés collaborate in the same embassy is limited by individual interest. Similarly, in the Czech Republic, previous efforts to design a wide network of science diplomats, which successfully established two science diplomats, but came to an end when the deputy prime minister of science resigned. The plan was not furthered, and the two science diplomats in position have continued their activities without direction or political guidance (Kadlecová et al., 2020).

In those examples, the instruments in place were not sufficiently met by other instruments. The presence of each type of instrument does not necessarily mean that the policy mix has been perfectly designed. Indeed, bottlenecks often arise during the development of instruments either because one instrument is missing (rupture) or due to the presence of diverging objectives (frictions). In the joint programming case (Flink, 2020), joint funding negotiations that took place between a European state with Egypt and Turkey were initiated as a result of high-level bilateral meetings. Thus, networking discussions established the development of an operational instrument. However, during negotiations, problems arose from the absence of another operational instrument, which would provide guiding principles regulating the programming procedure (Flink, 2020). Without a pre-established framework, it took four years for both parties to agree on a joint evaluation strategy. Despite the states working on scientific cooperation at several points for many years, there were no established methods to facilitate negotiations. Interviewees recommended introducing mechanisms as simple as reporting examples of successful and negative experiences as a base for further negotiations (Flink, 2020). Here, the creation of an operational instrument was slowed because negotiations were not sufficiently supported by a general policy on how to establish guiding principles. The absence of a pre-designed operational instrument hampered the smooth development of the joint funding scheme.

Beyond ruptures, frictions can also arise when the different institutions involved in the development of instruments push forward diverging objectives. For example, in the food security case (Ravinet et al., 2020), the drafting of calls for Horizon 2020 suffered from differences between the vision of the different Directorate Generals (DGs) on what kind of research should be fostered. While the DG for international cooperation and development pushed for more applied research which would foster development impact, DG Research and Innovation and DG Agriculture and Regional Development emphasized the need for excellence. The diverging visions have consequences for the type of research that is funded. In the food security case, calls that were drafted under Horizon 2020 fostered the excellence and innovation perspective, which resulted in proportionately less participation from African countries than during previous programmes (Ravinet et al., 2020). The diverging objectives worked against the aim of funding research which might have been more useful from a development goal perspective. In this case, frictions occurred during the creation of an operational instrument.

Similarly, in the case on joint research programming (Flink, 2020), frictions appeared between the objectives of the ministry and the funding agency negotiating which research was to be funded. In that case, the funding agency decided against funding certain research proposals until the ministry interfered and agreed to fund the projects that were originally rejected (Flink, 2020). Here, the political objectives of the ministry hampered the practical objectives of the agency, which lost credibility in that process. In the above-mentioned examples, frictions shape the outcome of the instrument, often in a sub-optimal manner.

Analysis of the case studies shows that while a plethora of instruments is available in all policy fields, ruptures and frictions are common. Often, the policy mix is not sufficiently developed, which leads to missing instruments, which creates ruptures in the workings of other instruments. Frictions, on the other hand, appear during the development of the instruments. While they can also be triggered by a gap in the instrument chain, they often arise from diverging objectives of the institutions which shape them. Identifying frictions and ruptures is important because they have an impact on how science diplomacy practices unfold. The teachable moments identified above illustrate the complex interdependence of instruments and of the multiple actors shaping them.

10. Rhythm and timing

Many global challenges may only be successfully addressed by connecting different epistemic communities and substantive domains with each other. Science diplomacy represents one such way of connecting, specifically, the science and diplomacy communities. How these communities connect and may in concert address global challenges, depends inter alia on their respective rhythms, i.e. typical sequences of action, and the timing of actions. As far as science diplomacy is concerned, and particularly when it relates to socio-ecological challenges, rhythms of other epistemic communities, such as politics, must be taken into account to the same extent as substantive domains, such as the economy and nature. Acknowledging the differences of rhythm between communities and domains is crucial for science diplomacy to optimize the timing of actions directed at addressing global challenges.

'Normal rhythms', i.e. sequences in which actions routinely or traditionally follow each other, differ between epistemic communities and substantive domains. Where they involve 'manmade' communities and domains, these rhythms are defined by the actors in their respective communities and domains. As such, a rhythm describes the general 'way things go' and not the rhythm of an individual actor[6]. Understood in this way, a rhythm is an emergent property of a community or domain. For instance, in politics, electoral cycles are typical devices ordering the communitys rhythm. Another example of different rhythms in that field pertains to the implementation of Open Science (Mayer, 2020). When the European Commission (EC) proclaimed Open Science as the new standard for scientific research, Member State reactions were mixed. Some complained that they had just transformed their national science sector into a competitive system as per the ECs previous recommendations and encouragements. Others accused the EC of moving too slowly to keep up with the developments in the field. Similarly, diplomacy has a rhythm defined by specific recurring events demarcated by international treaties, such as the conferences of the parties under the UN Framework Convention on Climate Change. These involve extensive sequences of preparatory actions. But also science, the economy or policy have their own rhythms. When it comes to science, this may be linked to processes of applying for research funding, executing research and starting this sequence over. The economy features rhythms of innovation, payback times or fiscal years. For many especially socioecological global challenges, rhythms of nature are also relevant. These may be sequences of chemical reactions with detrimental effects for human life on earth, as in the case of Chlorofluorocarbons and the ozone layer. But these rhythms may also refer to incubation time or infection numbers, as we have so overtly experienced in the COVID-19 pandemic (cf. Šlosarík et al., 2020). Various communities and domains rhythms also have more than one modality. Multiple modalities are visible in the diplomatic community, which has to deal with emergency situations, in addition to the planned processes of treaty work. In science, the traditional rhythm of laborious peer review may be juxtaposed by the more agile processes of Open Science. Finally, the dependence of different domains rhythms on each other is illustrated by the case of

6. For more details on actors involved in science diplomacy, see section on governance systems.

food security (Ravinet et al., 2020). The food production system demonstrates the interwovenness of this domain with other markets. For example, oil price fluctuations and their effect on costs of logistics may require diplomatic reaction to protect food production systems and supply chains.

From a science diplomacy perspective, 'timing', then, refers to the way in which actors purposefully or coincidentally align these various rhythms to interfere in 'norma' rhythms and modulate their future course to address global challenges. For science diplomacy, the timing of actions depends on whether they address an acute event or an ongoing process (response time and organization), whether they respond to an external impulse or initiate a new process (origin of the stimulus), or whether they break into an existing sequence to modulate it (transformative action). We have observed such transformative action in the Open Science case where science and policy rhythms aligned, generating international efforts to set up a European Open Science Cloud; efforts that were perceived as timely (Mayer, 2020). This feeling of timeliness stemmed from the fact that the effort would have gone awry ten years ago. On the contrary, such a public Open Science would have been obsolete in merely five years, when foreign companies, such as publishing houses, could have jumped on the opportunity. Thus, connective activities involve interference in and modulation of communities and domains rhythms that are simultaneously evolving through time. The timing of these interfering or modulating acts is crucial for them to be expedient. Whether timing is 'good' or 'bad' depends on the way in which science diplomatic interfering or modulating action has influenced other communities' or domains' rhythm. Furthermore, 'response time', i.e. the time needed to respond to an often unexpected specific event, is the time lag needed to align a communitys rhythm to another. The policy response to COVID-19 infections illustrates this: the rhythms of politics and policy had to be adjusted to react to the diseases rhythm. For example, in the Netherlands, from March 2020 lasting for several weeks, the decisions of an outbreak management team were communicated to the public in a weekly press conference, and weekly update sessions were organized for members of the Parliament. In several S4D4C cases (Kadlecová et al., 2020; Ravinet et al., 2020; Šlosarík et al., 2020), the response time to crises plays a role. To different degrees, countries have systems or crisis management strategies in place to respond to cyber-attacks or outbreaks of infectious diseases very quickly. Timing then involves a call-and-response pattern where a communitys rhythm adapts to modulating actions initiated by actors from other communities or domains.

Another aspect of timing is the problem of the simultaneity of counteracting rhythms as demonstrated by contrasting the two cases of Open Science and the FET Flagships (Mayer, 2020; Degelsegger-Márquez, 2020). The principle of Open Science champions collaborative and open sharing of scientific results and data with the aim of tackling global challenges. FET Flagships, on the other hand, were meant to significantly boost certain scientific fields within the EU as a mechanism to change the game regarding the availability of strategic STI. Here, timing the disclosure of scientific knowledge/results is caught in a conflict between scientific interests to share new knowledge as fast as possible, and economic or (geo-)political interests to share new knowledge only when certain actors have reaped the strategic and economic advantages. For scientific knowledge, these counteracting rhythms of Open Science versus FET Flagships illustrate that there is no absolute 'right' time to publish it. The expedience of actions directed at modulating other communities' or domains' rhythms also depends on the pursued interests. Science diplomacy can play different roles in relation to the rhythm of epistemic communities and substantive domains. First of all, it is a means of connecting and aligning the rhythms of the science and diplomacy community. Actions initiated as science diplomacy can target, but should at least take into account the rhythms of other communities and domains. Second, science diplomacy can serve as a means for understanding other rhythms by serving as an extra exchange channel for scientific knowledge, supported by mechanisms of Open Science. Third, science diplomacy aptness to connect communities and domains can be instrumentalized in cases of cyber-attacks or oil conflicts by attempting the alignment of counteracting rhythms. Thus, with an eye to the future, science diplomacy contributes to the normalization of relations between countries formerly or otherwise pitted against each other. Fourth, a perspective on timing as a means of aligning rhythms running counter to each other enables science diplomacy to look beyond emergency response exclusively, and work towards anticipation of crises as well. In sum, science diplomacy represents the purposeful synchronization of sciences and diplomacys rhythms to achieve synergistic effects in timing actions directed at interfering with and modulating other communities and domains rhythms to address global challenges.

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